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16. Abstract

A triaxial load pin array for measuring tire footprint pressures was recently purchased by TTI. This report describes our initial experience and results obtained with the array during a 3 month summer period in 1992. Footprint pressure distributions were measured for two highway-type radial truck tires (a conventional single and a wide base single) and a smooth tread truck tire. The data obtained compare well with footprint pressures measured at the University of Texas, Cooper Tire Co., and Goodyear Tire Co. Data showing the effects of tire inflation pressure and tire load on footprint pressure are included in the report.

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MEASUREMENT OF TIRE FOOTPRINT PRESSURES

by

John T. Tielking and Moises A. Abraham

Research Report 1184-3F
on
Research Study No. 2-18-89-1184
Using the Multidepth Deflectometer to Study Tire Pressure
and Dynamic Load Effects on Pavements

Sponsored by

Texas Department of Transportation

in cooperation with

The U.S. Department of Transportation
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September 1992

Texas Transportation Institute
Texas A&M University System
College Station, Texas 77843

METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
in	inches	2.54	centimetres	cm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
in^2	square inches	645.2	centimetres squared	cm^2
ft^2	square feet	0.0929	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
mi^2	square miles	2.59	kilometres squared	km^2
ac	acres	0.395	hectares	ha

MASS (weight)

Symbol	When You Know	Multiply By	To Find	Symbol
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg

VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.0328	metres cubed	m^3
yd^3	cubic yards	0.0765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

APPROXIMATE CONVERSIONS TO SI UNITS

LENGTH

Symbol	When You Know	Multiply By	To Find	Symbol
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi

AREA

Symbol	When You Know	Multiply By	To Find	Symbol
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
km^2	kilometres squared	0.39	square miles	mi^2
ha	hectores (10 000 m^2)	2.53	acres	ac

MASS (weight)

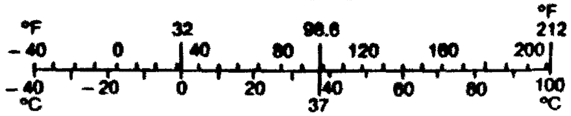
Symbol	When You Know	Multiply By	To Find	Symbol
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T

VOLUME

Symbol	When You Know	Multiply By	To Find	Symbol
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3

TEMPERATURE (exact)

Symbol	When You Know	Multiply By	To Find	Symbol
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



These factors conform to the requirement of FHWA Order 5190.1A.

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* SI is the symbol for the International System of Measurements

ABSTRACT

A triaxial load pin array to measure tire footprint pressures was recently purchased by TTI. This report describes our initial experience and results obtained with the array during a 3 month summer period in 1992. Footprint pressure distributions were measured for two highway-type radial truck tires (a conventional single and a wide base single) and a smooth tread truck tire. The data obtained compare well with footprint pressures measured at the University of Texas, Cooper Tire Co., and Goodyear Tire Co. Data showing the effects of tire inflation pressure and tire load on footprint pressure are included in the report.

A research program to systematically investigate other influences, such as tire nonuniformity and the effect of tread wear, on tire footprint pressures is outlined at the end of the report.

IMPLEMENTATION STATEMENT

The work presented in this report provides a framework for the Texas Department of Transportation to make quantitative decisions on the impact of truck/tire configurations on typical pavement structures. The study specifically addressed in this report focused on measurement of tire-pavement pressure distributions, commonly called footprint pressures. Knowledge of footprint pressure distributions is necessary to accurately predict pavement damage. Further work is needed to investigate the effects of tire nonuniformity and tread wear on footprint pressure.

DISCLAIMER

This report is not intended to constitute a standard, specification or regulation and does not necessarily represent the views or policy of the FHWA or Texas Department of Transportation. Additionally, this report is not intended for construction, bidding, or permit purposes.

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INTRODUCTION

Determining tire-pavement contact pressure distributions has become an important research need for further advancement in pavement design [1]. Today's truck tires, being radial with steel cord reinforcement, are believed to operate with footprint pressures that are considerably different from those of the nylon cord bias-ply truck tires for which most of the nation's highways have been designed. At present, very little information on tire-pavement pressure distributions produced by modern truck tires is available to the pavement designer.

A variety of methods have been used to measure contact pressure in the tire footprint. A pressure sensing film and a scanner/digitizer/analysis system were recently used at the University of Texas-Austin [2,3] in laboratory measurements of truck tire footprint pressures. Piezo electric sensors, now being developed for WIM, appear to provide realistic pavement pressure distributions [4] and are an approach that should be pursued for on-the-road measurements. The device that has been found most successful by the tire industry is the triaxial load pin. Several large tire companies and two government agencies (Air Force & NASA) have made their own load pins. Most of the work done by industry has been aimed at understanding tire wear and tread design. Goodyear has provided a set of footprint pressure measurements for pavement design purposes [5].

The Texas Transportation Institute (TTI) recently purchased a load pin array developed by the Precision Measurement Company of Ann Arbor, Michigan. This company has a long history of custom designing pressure sensing equipment. Their load pins have the smallest contact area, of those known to the authors, and are currently used by Cooper

Tire and the Pirelli-Armstrong Tire Company. The load pin has two important advantages over pressure sensing film: (a) Tire-pavement shear pressures can be measured with a triaxial load pin, and (b) The load pin signal will respond to dynamic tire contact pressure.

This report describes our initial experience, and results obtained, with the TTI load pin array during the 1992 summer months of June, July and August. The Texas A&M data are compared with data measured for the same size tires at the University of Texas, Cooper Tire Company and the Goodyear tire company. Recommendations are made for hardware improvements, and a research program to investigate tire-pavement contact pressures is outlined at the end of this report.

EXPERIMENTAL PROCEDURES

The normal contact pressures at different transverse locations for three different tires were obtained experimentally with tire loads applied by an MTS servo-hydraulic testing machine. A dual flange axle and a U-shaped load frame were used to position both wide base and conventional tires in the testing machine. The U-frame was bolted to a load cell which measures the resultant force in the tire footprint. In this set up, the axle is fixed (non-rotating) and the load is applied by a contact plate attached to the servo-hydraulic actuator. The actuator moves the contact plate up against the tire until a specified load is reached. Figure 1 shows the laboratory setup.

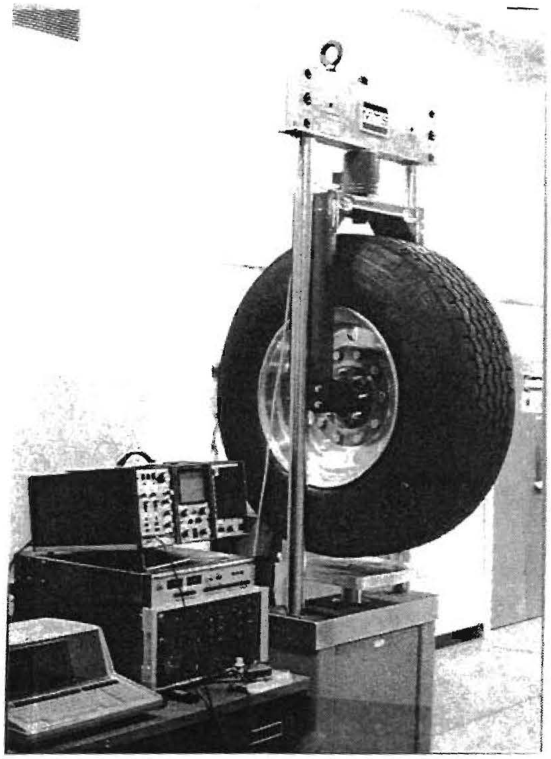

Figure 1. Wide base tire mounted in the MTS testing machine.

The contact plate is a 20x20x3 inch box made of half inch thick aluminum plates. A movable shoe with 10 load pins slides in the box in order to obtain data at different transverse locations. Each load pin has three strain gage channels from which change in voltage due to change in load can be read. Figure 2 shows the contact plate with the shoe inside. A steel scale along the edge of the shoe channel locates the lateral position of the load pin array.

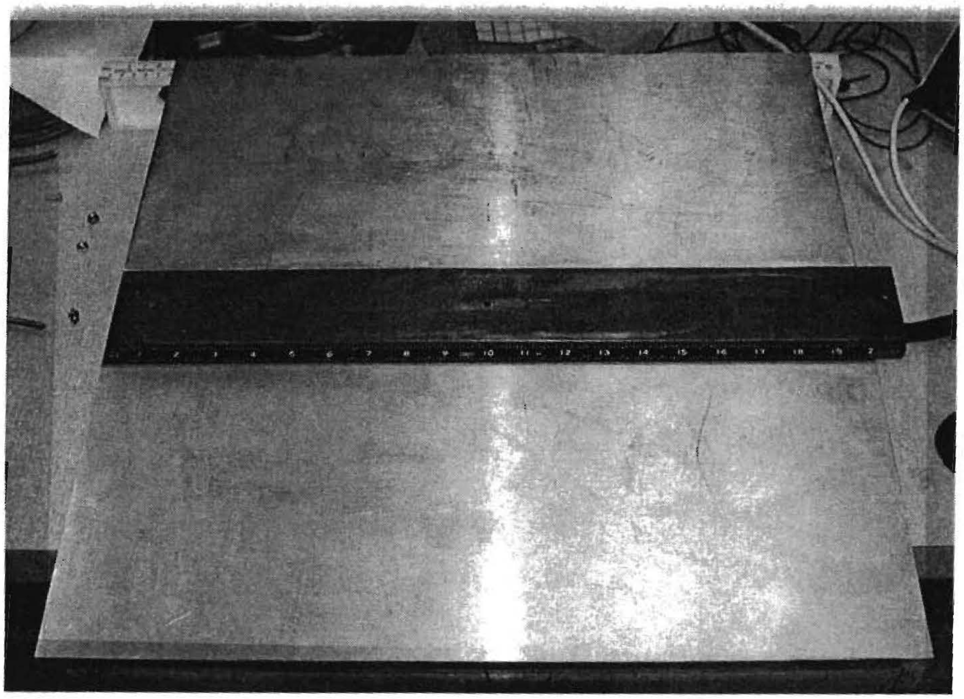

Figure 2. Contact plate and load pin array.

Data Acquisition

Data from the load pin array is acquired by a Daytronic Model 10K6 measurement and control unit. This unit is software controlled by a Compaq Portable 386 computer. A Daytronic program, DAS1, is used to obtain a live display of load pin data from the

Daytronic unit.

DAS1 displays data in sequential groups of 10 channels per screen page. This permits us to view the vertical force signal from all ten load pins simultaneously. The data displayed on the screen is bridge voltage (in millivolts), which changes with load. Figure 3 shows how data appears on the computer screen.

```
DAYTRONIC  PROGRAM  DAS1
 CH  1:  24       CH  6:  34
 CH  2:  15       CH  7:  19
 CH  3:  -120     CH  8:  20
 CH  4:  0        CH  9:  -25
 CH  5:  -29      CH  10:  2
```

Figure 3. Display of data from program DAS1.

As described earlier, the shoe is moved in the contact plate in order to obtain readings at different transverse locations. Figures 4, 5 and 6 show the location of the pins with the shoe at three different positions. The footprint shown is that of an 11R22.5 tire at 6040 lbs load and 105 psi inflation pressure. The location of the pins is needed in order to identify the distance from the center of the tire at which each contact pressure is obtained. The filled circles in Figs. 4, 5, and 6 show the actual contact areas of the load pins.

The procedure adopted to calculate the normal pressures is as follows. Firstly, initial

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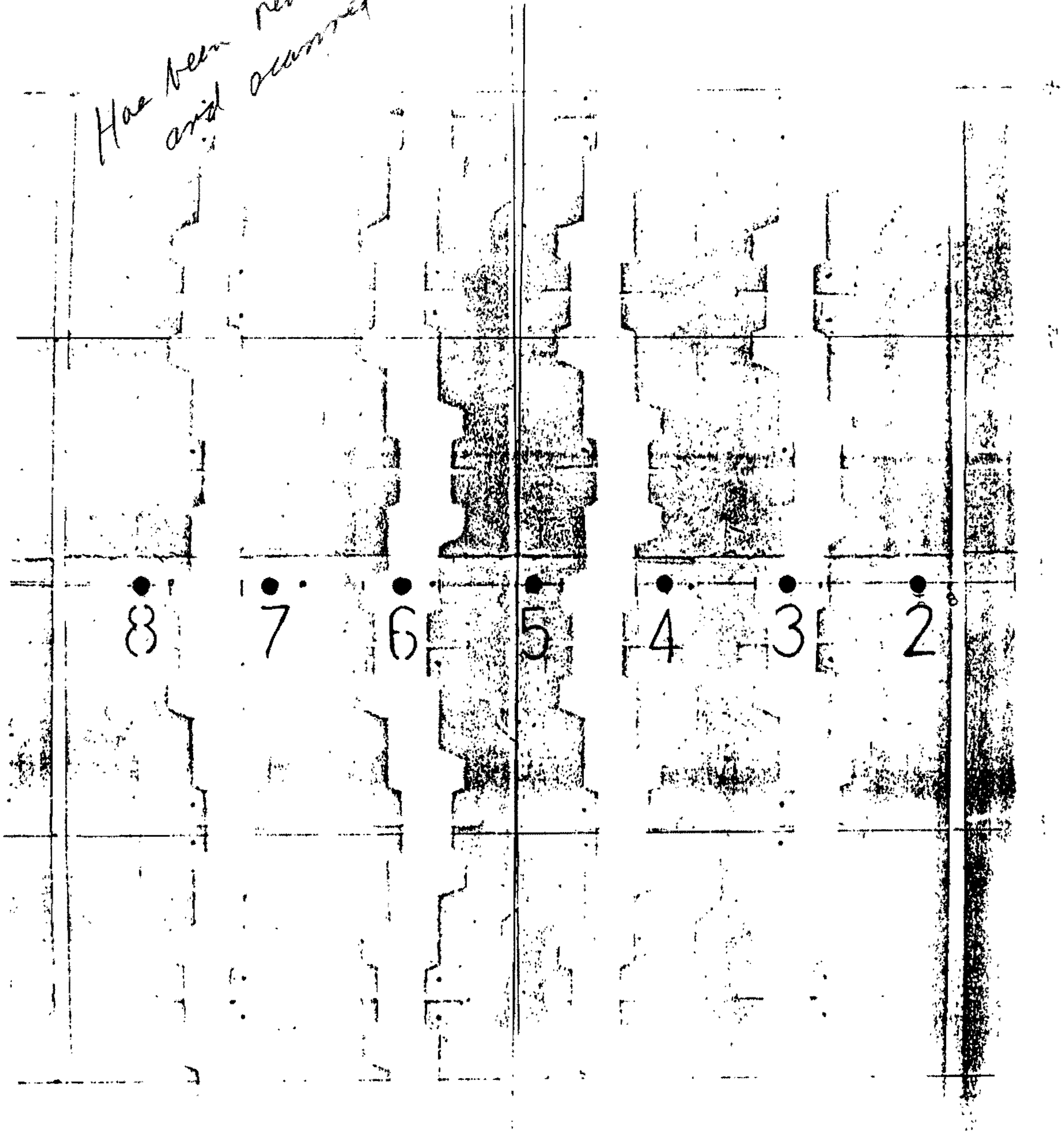

Figure 4. Load pin array with shoe at position 1 (D = 16.1 in).

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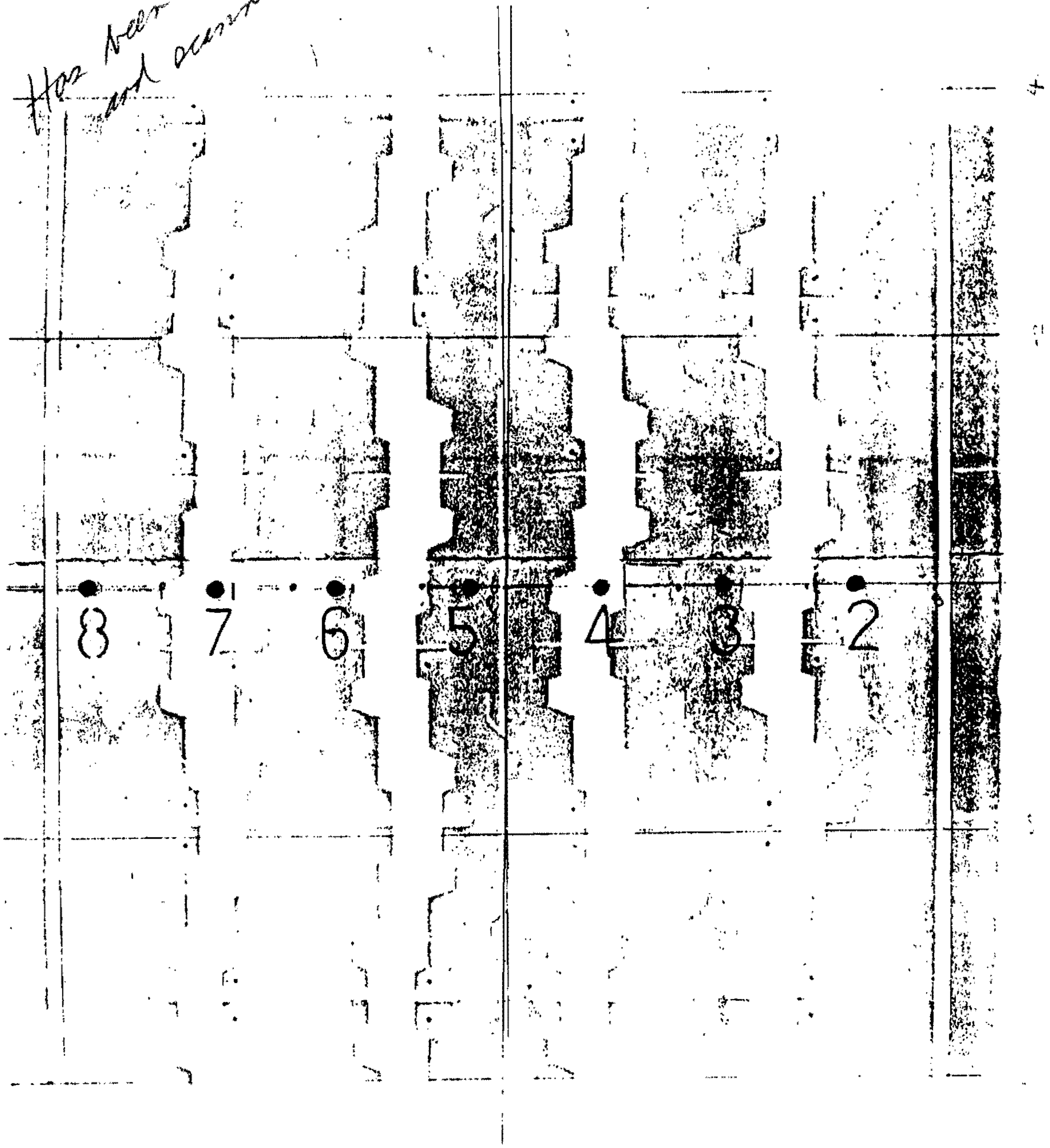

Figure 5. Load pin array with shoe at position 2 (D = 16.5 in).

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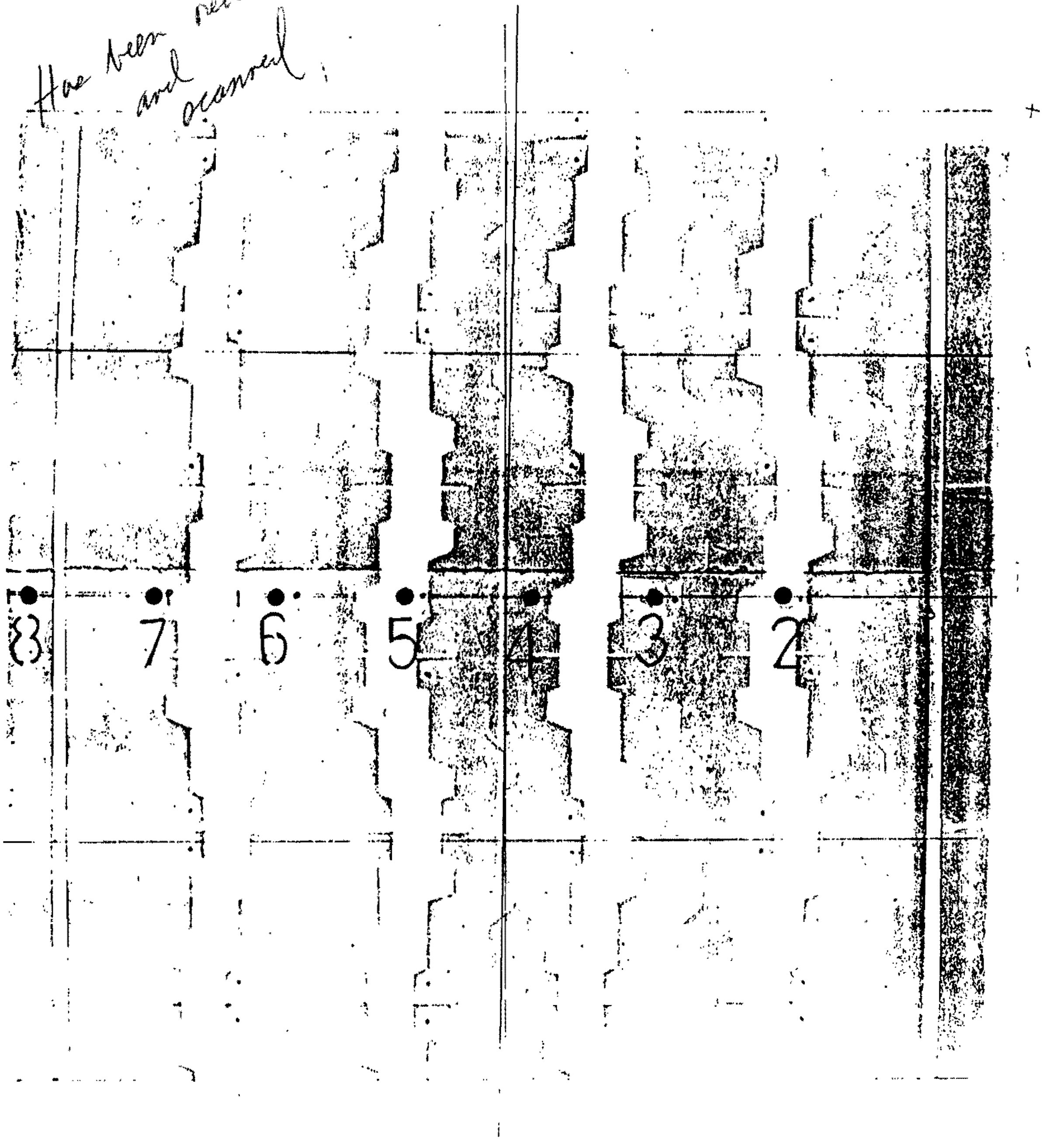


Figure 6. Load pin array with shoe at position 3 (D = 17.0 in).

channel readings are obtained for each load pin (no load applied). Secondly, the tire load is applied by moving the contact plate up against the tire, and a second set of readings is obtained. Finally, the difference between the two readings and the calibration lines for each load pin are utilized to calculate the normal pressures. This procedure was repeated for each position of the shoe along the transverse median of the footprint. Table 1 shows the readings obtained for the 11R22.5 tire at 6040 lbs load and 105 psi inflation pressure.

Table 1. Example data for the 11R22.5 tire at 105 psi & 6040 lbs

	D = 16.1 in			D = 16.5 in			D = 17.0 in		
pin	V_i	V_f	p	V_i	V_f	p	V_i	V_f	p
3	-7354	-7354	0	-7354	-7874	118	-7354	-7844	108
4	-75	-538	111	-79	-81	0	-82	-906	214
5	-2	-795	104	-3	-745	95	-5	-5	0
6	-49	-49	0	-45	-1014	155	-47	-741	118
7	34	-301	54	33	33	0	33	-578	93
8	51	-577	119	62	-420	92	52	-363	85

V_i = initial voltage (mv)
V_f = final voltage (mv)
p = corresponding pressure (psi), from calibration data

The values of D in Table 1 are the three positions of the load pin shoe at which these data were taken. The pin locations on the tread pattern, for each shoe position, are shown in Figs. 4, 5, and 6. Pin 2 was inoperative when these data were taken, so two more shoe positions were used to collect data on rib 5, using pins 3 and 4. At D = 17 in., pin 5 shows zero pressure (Table 1). Referring to Fig. 6, we see that pin 5 is positioned over a groove (white space on footprint) and thus should not record a pressure. Figure 7 gives the values of the pin locations relative to the tread center. The information in this figure, together with Table 1, allows us to organize the pressure data sequentially across the footprint.

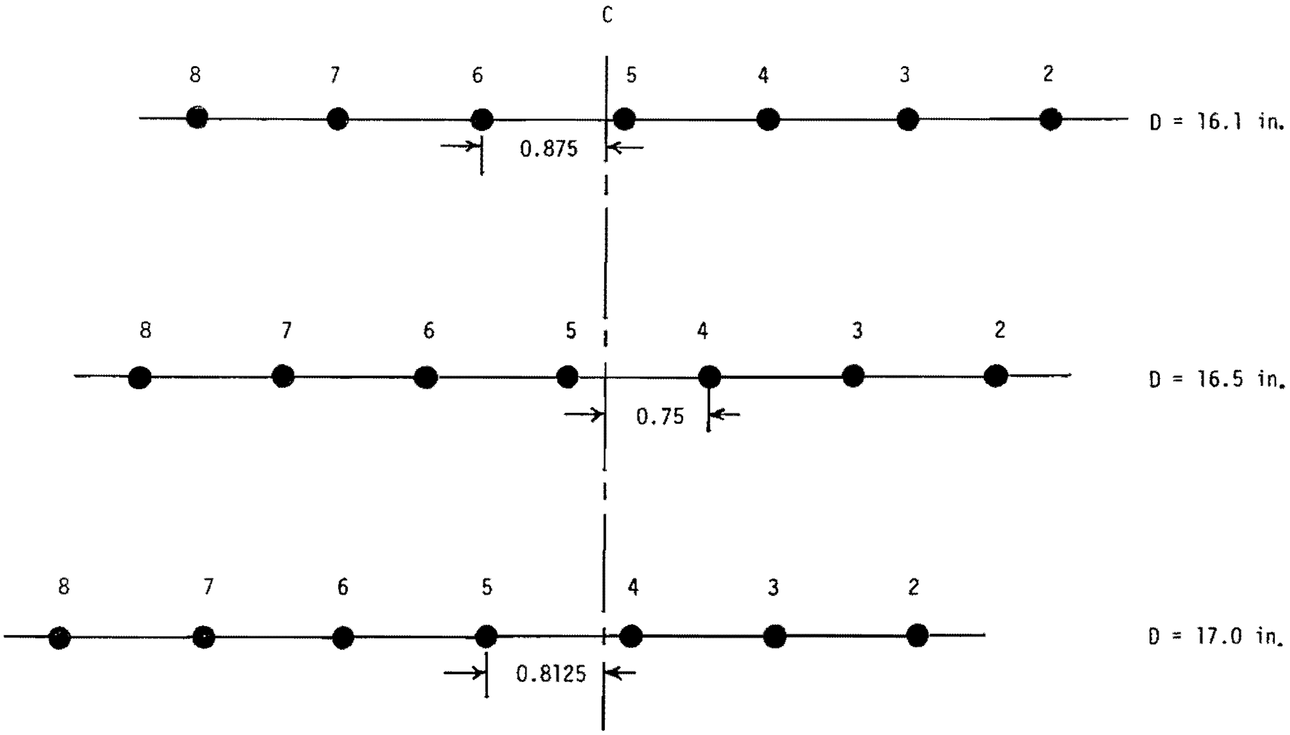


Figure 7. Pin locations relative to tread centerline C.
(Pin centers are spaced 1 inch apart)

Table 2 shows the sequential data taken from Table 1 (and 2 other shoe settings). These data show considerable variation in the pressures across a rib. The rib pressures were averaged to make the plots in this report, showing the effects of inflation pressure and tire load on the footprint pressure distribution. Table 3 shows the average rib pressures calculated from the data in Table 2. The data in Table 3 are plotted in Fig. 13 (11R22.5 at 105 psi & 6040 lb load).

Table 2. Measured Pressures

Distance (in.)	Pressure (psi)	
-3.8125	85	
-3.25	92	rib 1
-2.875	119	
-2.8125	93	
-1.875	54	
-1.8125	118	rib 2
-1.5	142	
-1.25	155	
-0.25	95	
0.125	104	rib 3
0.1875	214	
1.125	111	
1.1875	115	
1.5	150	rib 4
1.75	108	
1.8	118	
1.9	105	
2.8	86	
2.9	80	rib 5
3.9	118	

Table 3. Average rib pressure

Distance (in.)	Avg. Pressure (psi)	
-3.9	0	
-3.3	97	rib 1
-1.6	117	rib 2
-0.02	138	rib 3
1.54	118	rib 4
3.33	95	rib 5
3.9	0	

Calibration

In the procedure above, pin calibration lines are utilized to calculate the normal contact pressures. To obtain these lines, prescribed loads were applied to each pin by means of an aluminum load block. The load block is cylindrical with a rubber pad having a contact area of 0.636 in^2. An INSTRON 1125 testing machine was used for this purpose. Figure 8 shows the laboratory setup for calibration of the load pins. Once the loads and changes in voltages were recorded, plots of pressure versus change in voltage were made for each pin. These are the calibration plots shown in Fig. 9.

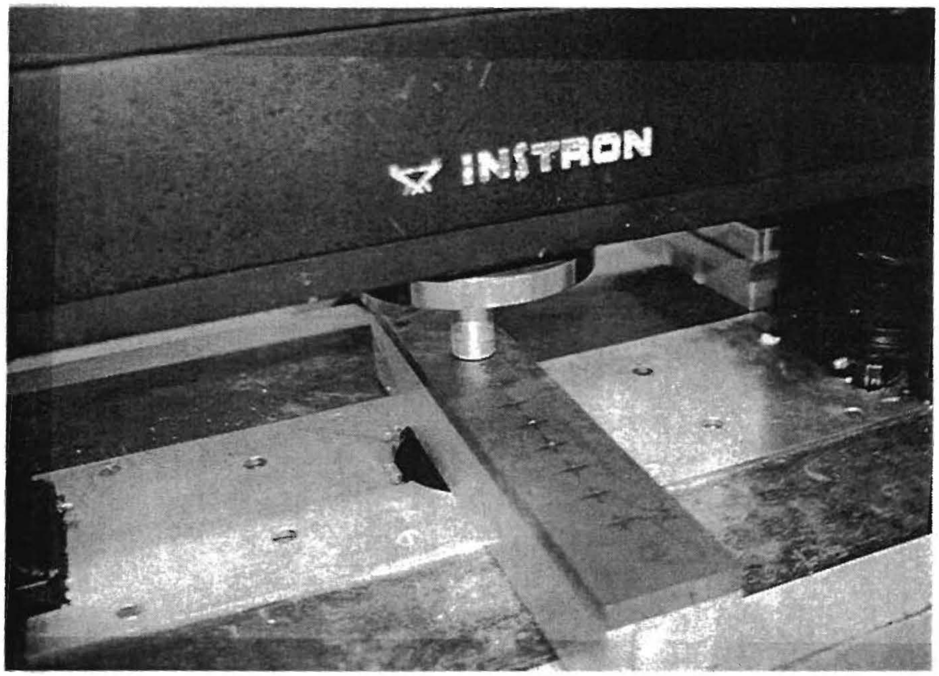
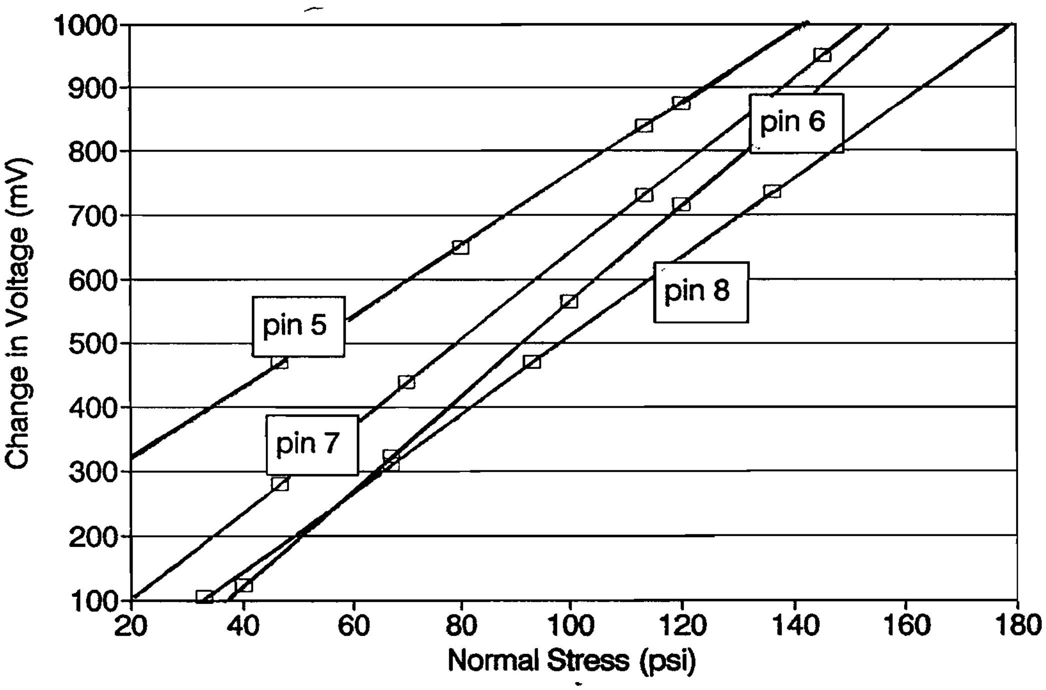


Figure 8. Laboratory setup for load pin calibration.



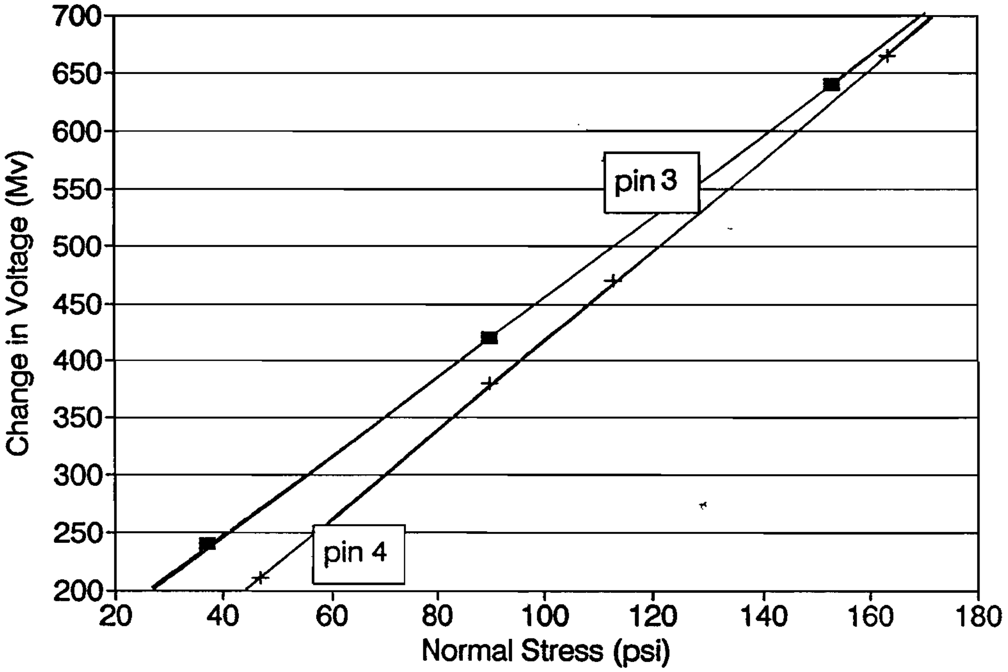


Figure 9. Load pin calibration lines.

RESULTS

Footprint pressure measurements were made on three different tires, listed in Table 4.

Table 4. Design parameters of tires tested

Tire Size	Inflation Pressure (psi)	Load Limit (lb)	Tread Pattern
11R22.5/G	105	6040	5-rib
11R24.5/G	105	6430	none
385/65R22.5/J	120	9730	6-rib

The load limits given in Table 4 are for single tire application with the tire inflated to the design pressure. These values are taken from the 1992 Tire and Rim Association Yearbook. A slightly lower inflation pressure and load limit are specified when the tire is used as a dual.

The 11R22.5 size is a conventional radial truck tire, used either as a single, in the steer position, or as duals on drive and trailer axles. The 385/65R22.5 is a wide base tire that is a possible replacement for a dual tire set. These two tires have highway rib-type tread patterns, as pictured in Fig. 10. The 11R24.5 tire (not shown) is a conventional truck tire made with a patternless tread for research purposes. The experimental results obtained with each of these tires are given in the following sections.

Smooth Tread 11R24.5

This tire has a full tread layer molded without a tread pattern. The smooth tread eliminates the pressure gradients found at rib edges and avoids the difficulty of interpreting data when the load pin spans a kerf (a narrow cut in the tread pattern). This tire has been

Figure 10. Conventional (left) and a wide base truck tire.

tested previously by the University of Texas [2] using pressure sensitive film (Fuji film), and by the Cooper Tire Company using a load pin array like ours.

Figure 11 shows the contact pressures measured by the University of Texas (CTR) along the transverse median[1] of the footprint. Slight surface imperfections are responsible for the scatter of the measured pressures. The 95 psi peak at the center of the footprint is caused by the mold parting line, a small ridge of rubber around the tread circumference. The data points measured by our load pin array (TAMU data) are shown with an X in Fig. 11.

Figure 12 shows the contact pressure distribution measured by Cooper with the tire at a different inflation pressure and a different tire load. Our data points for this pressure and load are shown with an X.

The agreement between our measurements and those of the University of Texas (CTR) and the Cooper Tire Company is very good, considering the sensitivity of interfacial pressure measurements. Having developed our test procedures with the smooth tread tire, we proceeded to work with two tires having highway tread patterns.

11R22.5/G (Conventional Truck Tire)

Footprint pressures were measured for the 11R22.5 tire at two inflation pressures (105 psi, 80 psi) and at two tire loads (6040 lb, 8000 lb) for each inflation pressure. Figures 13 and 14 show the effect of tire load on footprint pressure for the tire inflated at 105 psi and 80 psi, respectively. These data show the pressure distribution to become somewhat

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[1] The transverse median runs through the center of the footprint, along the maximum contact width. All data in this report were taken along this median.

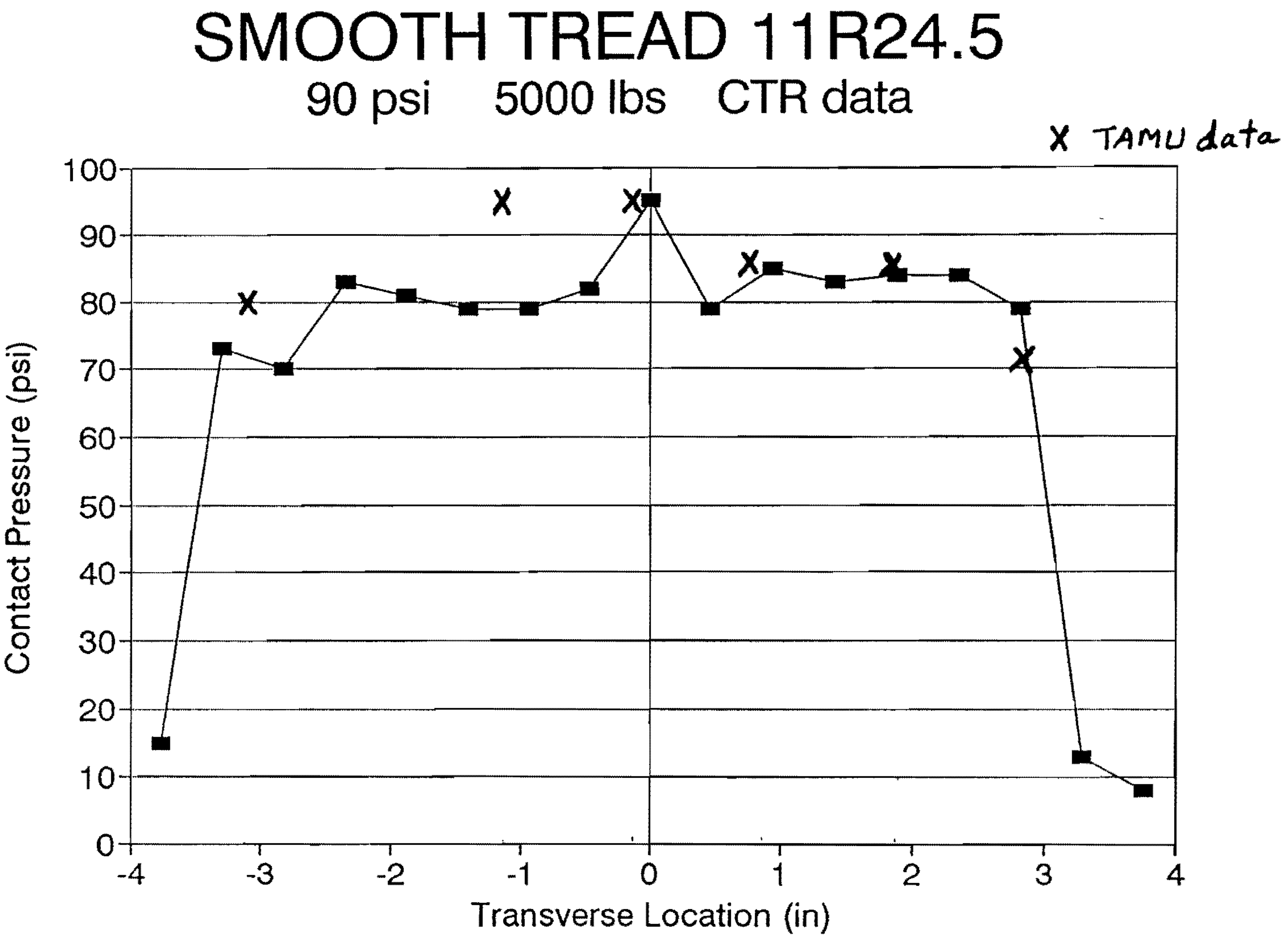

Figure 11. Comparison of data measured at Texas A&M (X) with data measured at University of Texas (■).

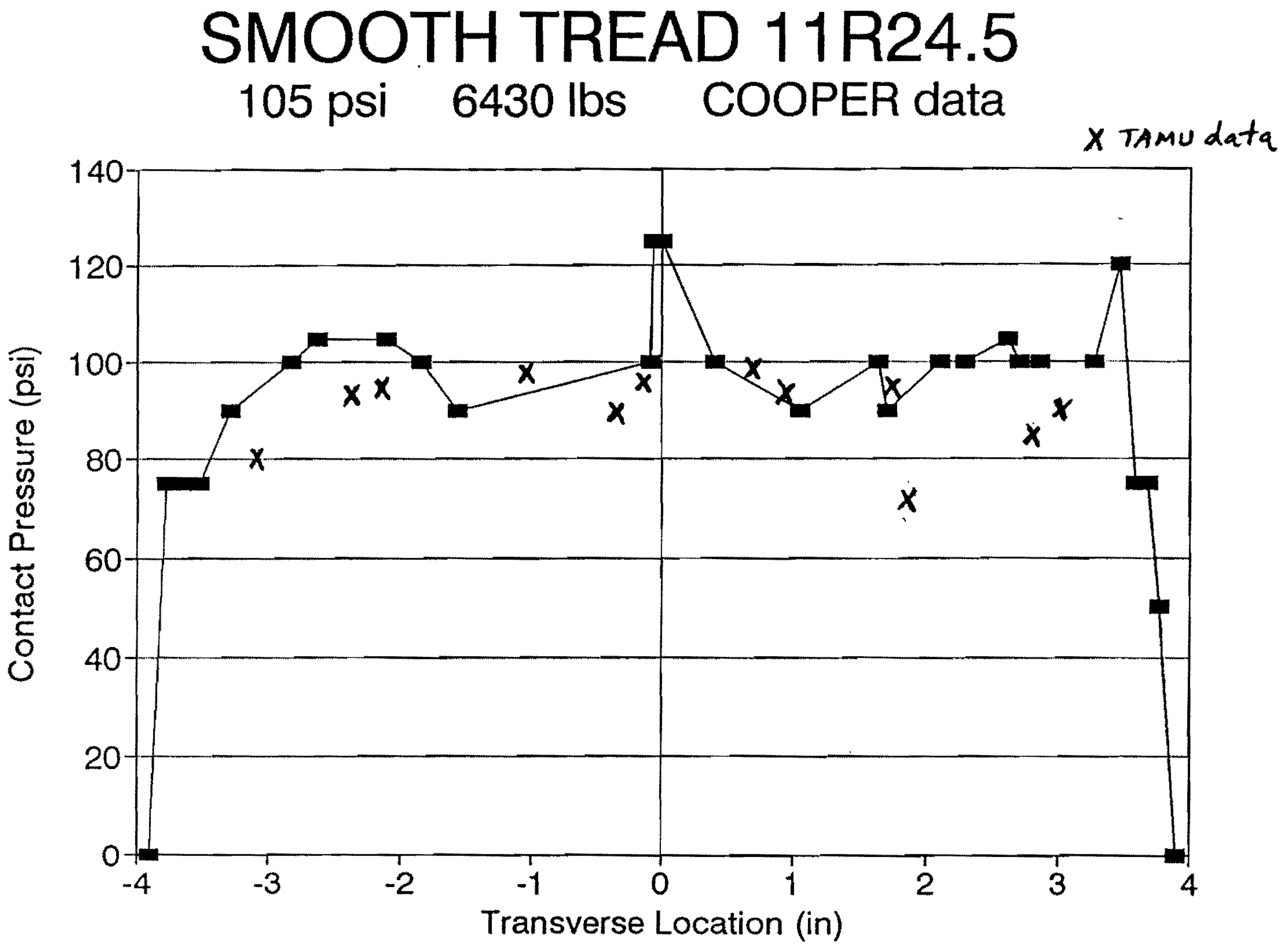

Figure 12. Comparison of data measured at Texas A&M (X) with data measured at Cooper Tire Co. (■).

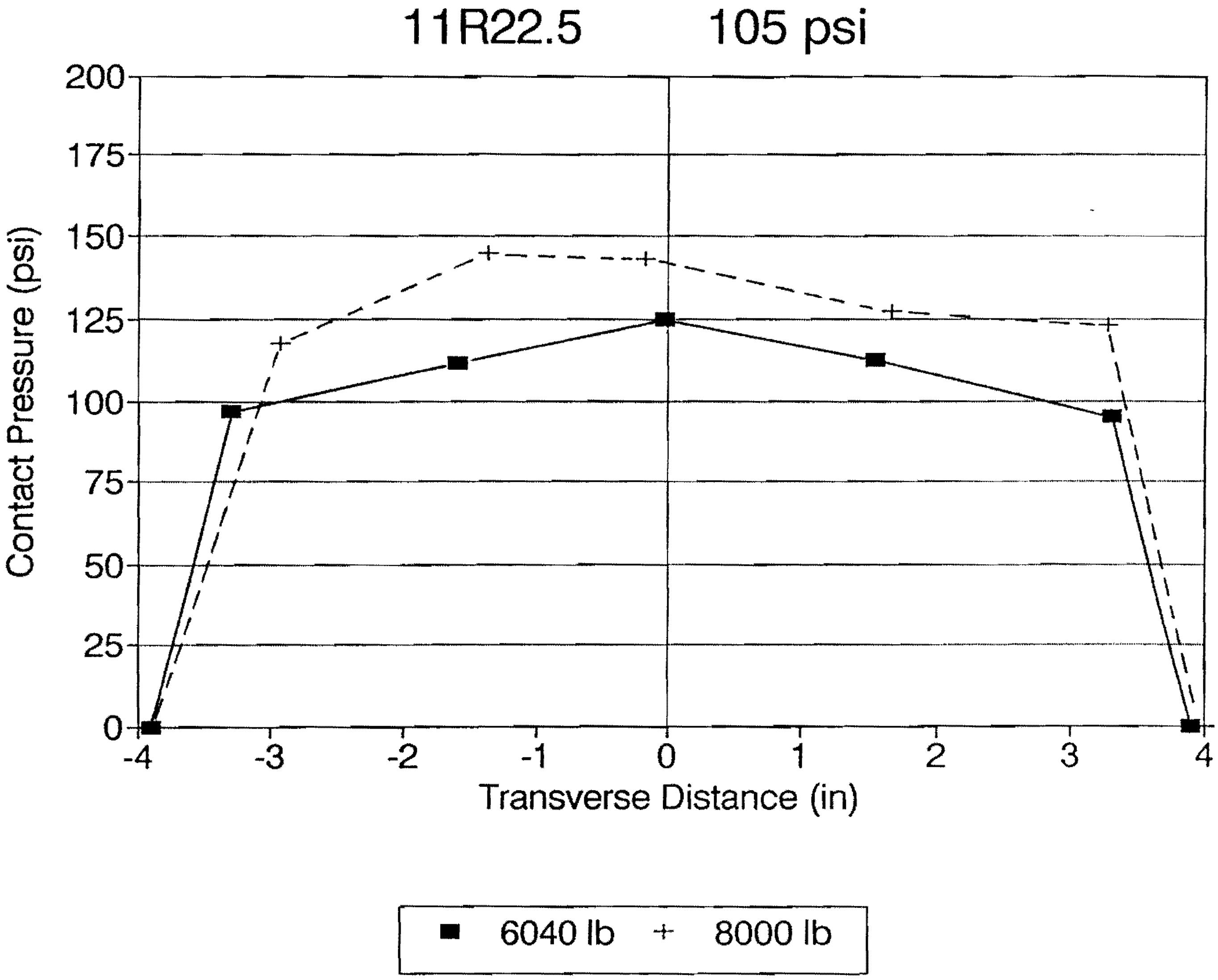

Figure 13. Effect of tire load on footprint pressure of the 11R22.5 tire at 105 psi inflation pressure.

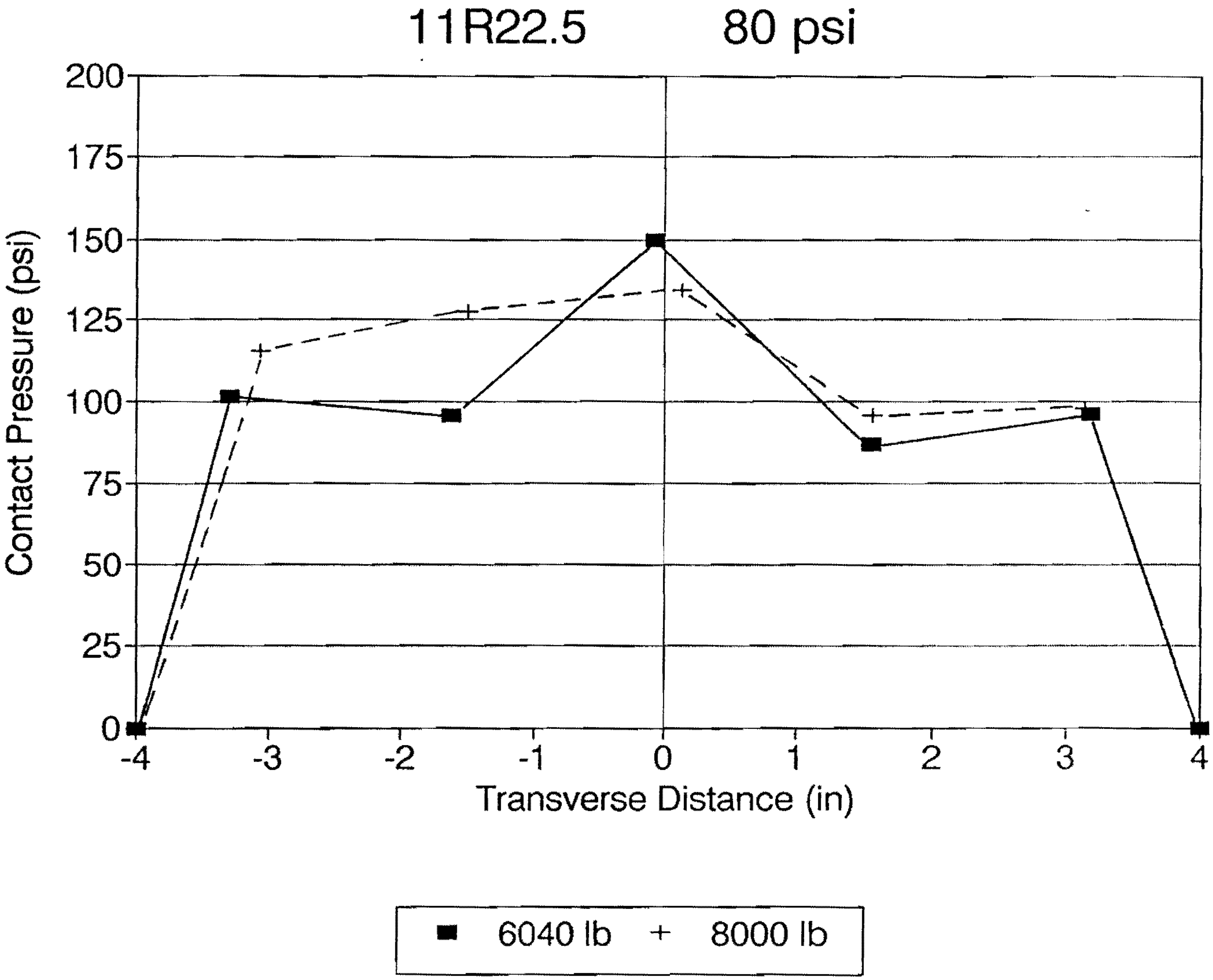

Figure 14. Effect of tire load on footprint pressure of the 11R22.5 tire at 80 psi inflation pressure.

more uniform as tire load is increased. As may be expected, the average pressure at the higher load is also higher. Table 5 gives the average contact pressures for the data shown in Figs. 13 and 14. Each value in Table 5 is the average along the transverse median. The average over the entire footprint will be somewhat different. It is well-known, to tire engineers, that the average footprint pressure produced by a tire can be above or below the inflation pressure, depending on tire load. This effect has also been calculated [6].

Table 5. 11R22.5 average contact pressures

Inflation (psi)	Load (lb)	Avg. Pressure (psi)
80	6040	106
80	8000	114
105	6040	113
105	8000	131

It is noted in Figs. 13 and 14 that the contact pressure is not exactly symmetric about the tire plane of symmetry. This is due, in part, to tire nonuniformity. It is also believed due to the conventional truck tire being mounted on a wheel with an offset flange. A typical truck wheel is sketched in Fig. 15. The wheel mounting flange is offset about six inches from the tire plane so that the same wheel can be used for dual tires or for single tires. In Figs. 13 and 14, the tire load is applied through the wheel flange at -6 in. from the center of the tread (transverse distance). This effectively cantilevers the tire and is believed to contribute to the slight dip in the contact pressure at about +1.5 in. from the tread center. This effect has apparently not been previously noticed. It should be further

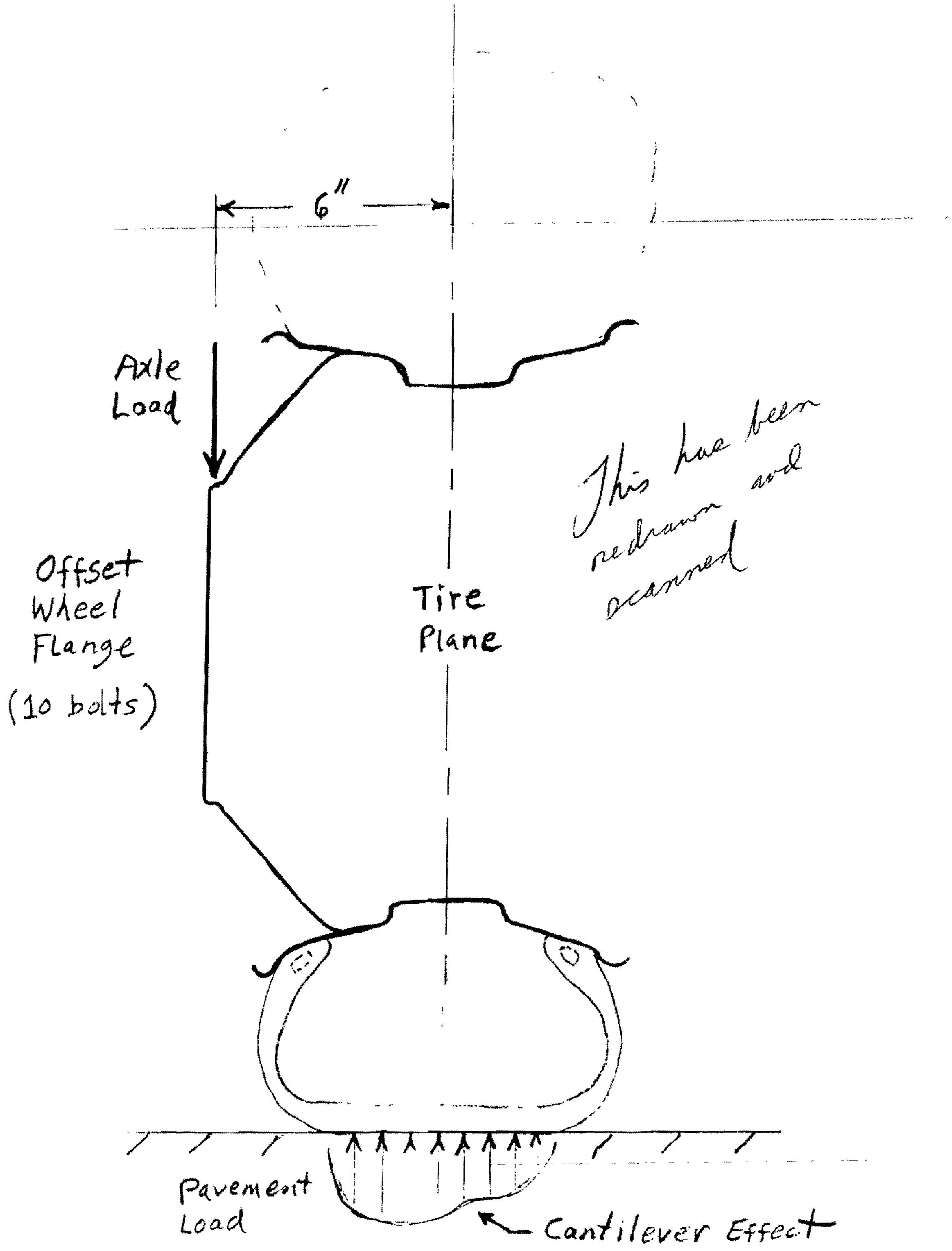

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Figure 15. Truck wheel with offset flange. Effect on pavement load.

investigated as nearly all conventional truck tires are mounted on a wheel with an offset flange.

385/65R22.5 (Wide Base Truck Tire)

This tire was mounted on a center flange wheel to eliminate the cantilever effect described above. Offset flange wheels are also used to mount wide base single truck tires, but the offset (nom. 3.75 in.) does not extend outside the contact region, so the cantilever effect will probably be imperceptible.

Footprint pressure data on this size tire were previously measured by Goodyear for pavement studies at the Pennsylvania Transportation Institute [5]. Figure 16 compares the Goodyear data with our data for this tire inflated to 130 psi and with an 8500 lb load. The agreement here is fairly good except on the two central ribs where our measurements show about 75 psi higher contact pressure. We believe this can be due to tire variability, perhaps caused by slight difference in the tire molds. It has not been determined that the tires tested by TAMU and Goodyear came from the same mold, or from the same tire building machine.

Footprint pressures were measured at two other tire inflation pressures (120 psi, 95 psi) and at two tire loads (6000 lb, 9000 lb) for each of these pressures. Unlike the conventional truck tire, virtually the same footprint pressures along the transverse median were found for these two tire loads, with the tire at the same inflation pressure. (The additional load is carried by a longer footprint.) However, inflation pressure has a significant effect when the tire load is held constant. This is seen in Figs. 17 and 18, for the 6000 lb and 9000 lb loads, respectively.

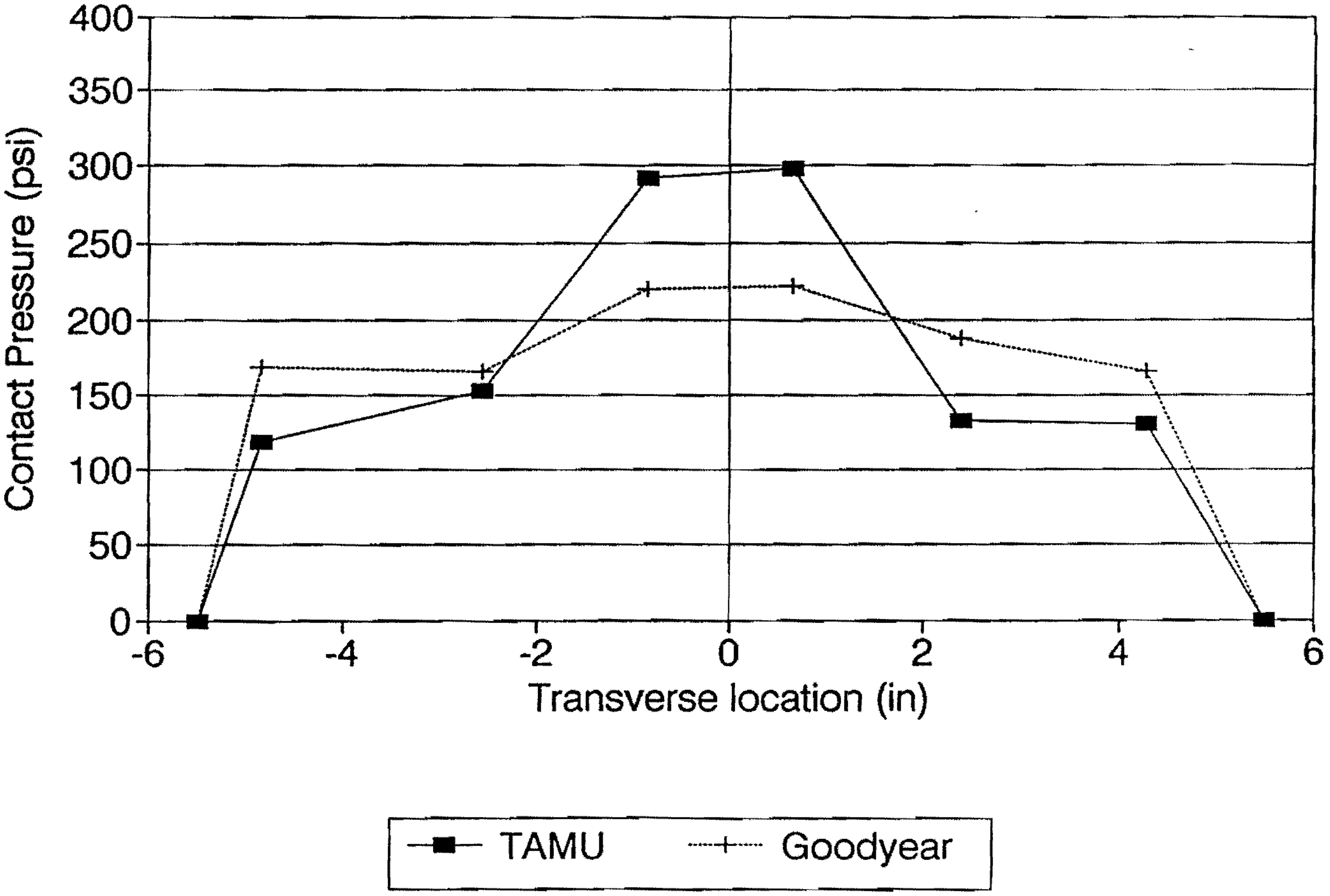

Figure 16. Comparison of data measured at Texas A&M with data measured by Goodyear for the 385/65R22.5 tire at 130 psi inflation pressure and 8500 lb load.

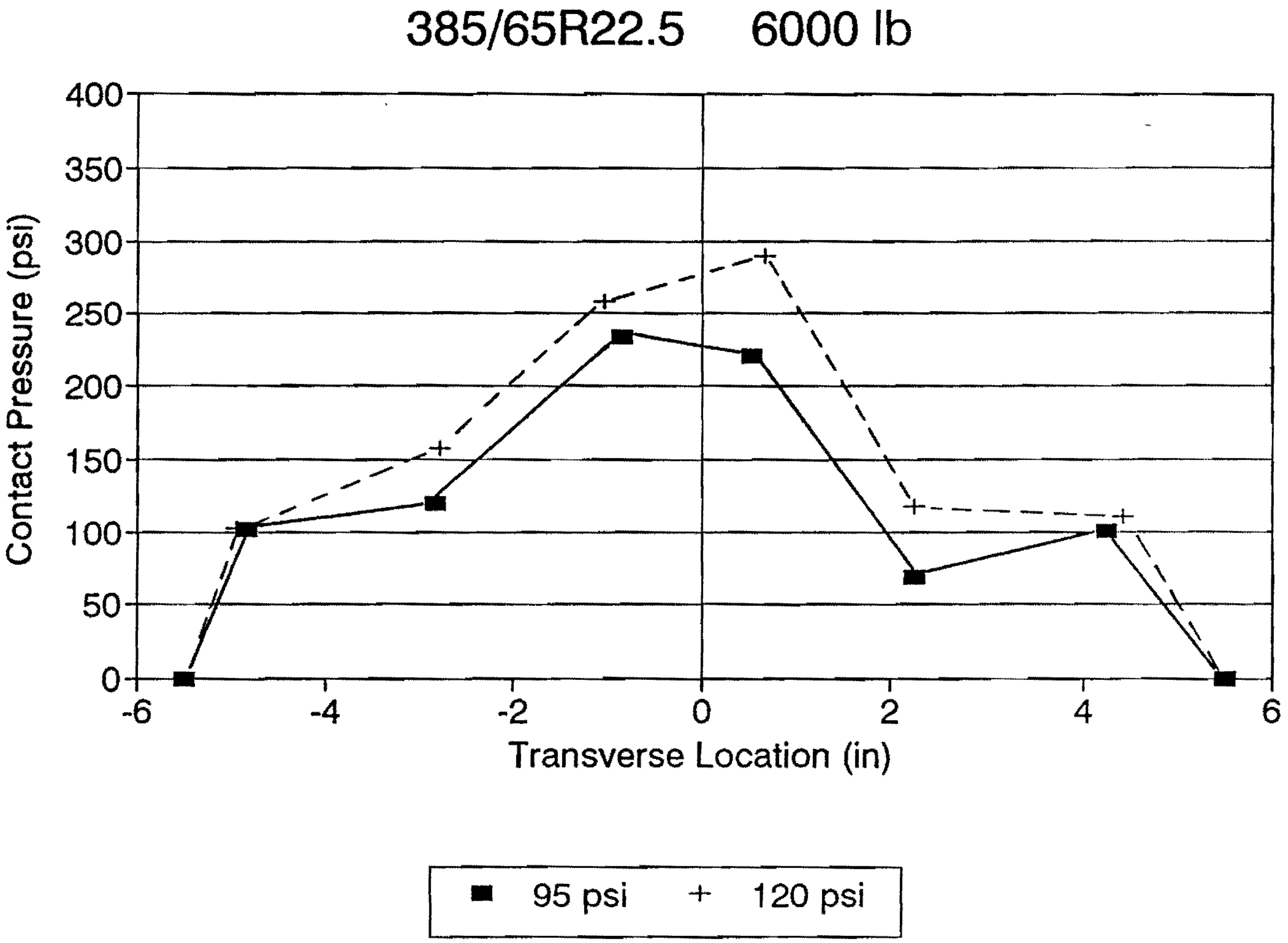

Figure 17. Effect of inflation pressure on footprint pressure of the 385/65R22.5 tire with 6000 lb load.

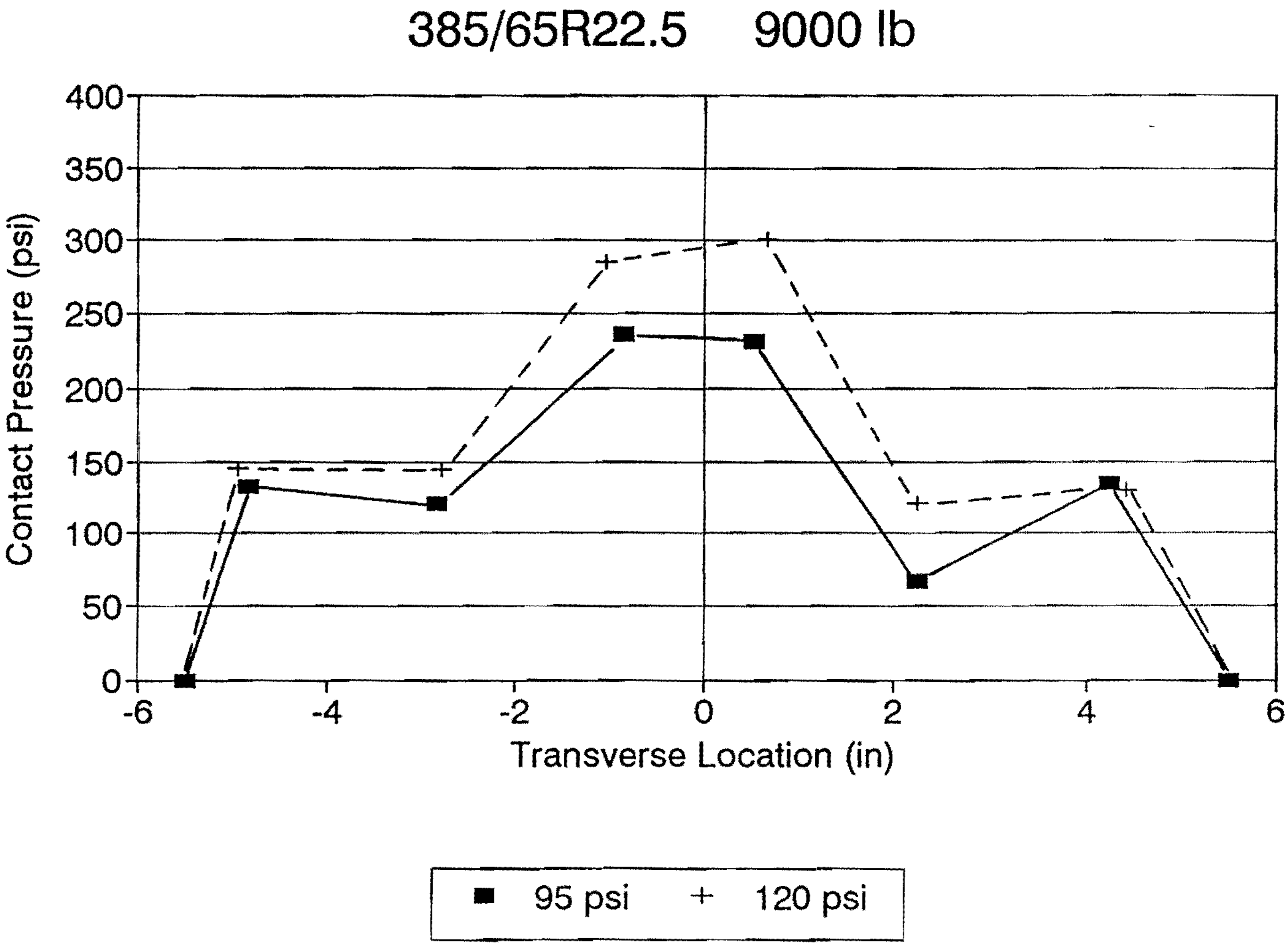

Figure 18. Effect of inflation pressure on footprint pressure of the 385/65R22.5 tire with 9000 lb load.

Table 6 gives the average contact pressures for the data shown in Figs. 16, 17 and 18. As in Table 5, these averages are taken along the transverse median of the footprint, and are not averages over the entire footprint.

Table 6. 385/65R22.5 average contact pressures

Inflation (psi)	Load (lb)	Avg. Pressure (psi)	Data Source
130	8500	189	Goodyear
130	8500	189	TAMU
120	9000	188	TAMU
120	6000	173	TAMU
95	9000	154	TAMU
95	6000	141	TAMU

DISCUSSION AND RECOMMENDATIONS

This section gives our suggestions for enhancing the equipment and efficiency of data acquisition. Several areas of investigation, considered essential for understanding tire-pavement footprint pressures, are also described.

Equipment Enhancements

In its present form, the equipment was adequate for the pilot study reported herein. For a larger project of footprint pressure measurements, such as one of the studies outlined here, several improvements should be considered.

1. Dedicated Load Frame

Currently, the tire is mounted on a standard truck wheel which is bolted into a U-shaped frame that was specially designed to fit the 20 kip MTS servo-hydraulic testing machine in the TEES Materials Laboratory. Figure 1 shows the wide base tire mounted in the testing machine. The MTS machine has far more capability than is needed for our work, and it is unreasonable to occupy it for the extended period of time needed for tire testing.

The Laboratory Manager, Toby Selcer, has offered to design a dedicated load frame for truck tire testing. This would use one of the portable hydraulic actuators, which are seldom used, and a basic controller that can be dedicated to tire testing. Toby estimates the design and fabrication cost at about $5,000. This would give us a stand-alone laboratory facility for truck tire testing, capable of dynamic as well as static loading.

2. Contact Box Positioning Mechanism

At present, the tire contact box slides freely on the actuator table. It is manually positioned beneath the tire, with the aid of a steel ruler and a drafting triangle. The sliding shoe (load pin array) is positioned with a steel scale along the shoe trench in the contact box. As we are presently averaging the pressures found at several locations across a rib, this locating method is adequate. It is desirable for a more detailed study to develop mechanical screw-driven mechanisms for positioning the contact box and its sliding shoe. This would greatly improve our ability to identify exactly where the load pins are under the tire, and eliminate the possibility of the contact box being accidently bumped out of position.

3. Software Control of Data Acquisition

Raw data are currently acquired manually, on pencil and paper as follows.

(a) The initial channel values are read for each load pin before the tire is put into contact.

(b) Operator raises the actuator to put the tire into contact at the specified tire load. Wait for channel values to stabilize (when tire reaches static equilibrium).

(c) The final channel values are read for each load pin.

(d) Operator lowers the actuator to remove the tire load. The shoe (load pin array) is moved to a new position under the tire. Steps (a-c) are repeated.

Since the data channels are being displayed on the Compaq computer monitor, using the Daytronic software, it should be possible to have the computer store the initial and final channel values, instead of copying these from the screen. The control program should be set up to do this for each position of the load pin array. It would be desirable to put the channel values on a floppy disk for subsequent data processing.

4. Data Processing Software

A computer program is needed that can read the channel values and load pin array positions saved on the floppy disk mentioned above. This program will subtract the initial and final values for each channel and use the pin calibration data to convert each result into a pressure value. Having the load pin array positions, the program could also set up a table giving the location and pressure at each point on the tread where a measurement was taken (e.g., Table 2). A plot would be made to show all of the pressures found at a specified tire load. The program could also produce a table and plot showing the average pressure on each rib. The plot showing the distribution of average rib pressures is the data display method used in this report (Figs. 11-18).

Essential Investigations

Preliminary measurements, made to investigate the effects of tire load and inflation pressure, have revealed considerable variability in the footprint pressure distributions. Tread wear and tire nonuniformity are two possible sources of footprint pressure variability. The following investigations are recommended to quantify the variability to be expected in tire-pavement contact pressures.

1. Effect of Tire Footprint Location

Tire uniformity (roundness) has a significant effect on dynamic behavior, such as noise and ride. However, no data are available on circumferential uniformity of the footprint pressure. This can easily be investigated by rotating the tire and repeating the footprint pressure measurements. With our present equipment, we can conveniently rotate the tire 90° and then repeat the pressure measurements. It is recommended that this be done for four equally spaced footprints on each of the three tires tested in the pilot program. It will also be worthwhile to repeat the measurements on a second tire of the same size and tread pattern, to investigate tire-to-tire variability.

2. Effect of Tread Wear

It is well-known that tread wear affects the cornering characteristics of a tire. This may be due, in part, to changes in footprint pressure caused by tread wear. Including both worn and new tires of the same size and design in the next test program is recommended.

3. Effect of Tire Type

At present, we have tested one conventional and one wide base tire with highway type tread patterns. Low profile tires continue to be popular, and should be studied as well. Another study may be desirable to investigate footprint pressures of the special tires that are used to carry extra heavy loads (permit loads).

Further Considerations

The measurement of tire footprint pressures will become increasingly important, and more pavement research organizations will attempt to do it. Figure 19 is an example of very realistic on-the-road dual tire footprint pressures measured with piezoelectric sensors (a WIM system). Unfortunately, the reference [4] from which this figure was taken gives no details about the tires; the size, type, inflation pressure, and load are not given.

Detailed communication and comparison of data are essential. Differences found should be investigated until they are reconciled. It would be desirable to have a national organization take an active interest in this work, acting as a clearinghouse (for the data conflicts) and as a coordinator. Thorough documentation is essential.

Finally, and no less important, the study of tangential tire-pavement pressures should begin soon. This is far more difficult than the study of normal pressures for two reasons.

1. Tangential pressures generated by rolling tire contact are very different from those produced by vertical tire contact. The differences are discussed in [7]. The capability to roll a tire into contact will require significant equipment modifications.

2. Tangential ~~pressures are modulated by friction in the tire-pavement interface. It is~~ therefore essential that the contacting surface have a texture that is representative of a highway surface.

The above concerns do not apply to the normal pressure distribution, which, for a free-rolling tire, is only slightly affected by rolling speed and tire-pavement friction.

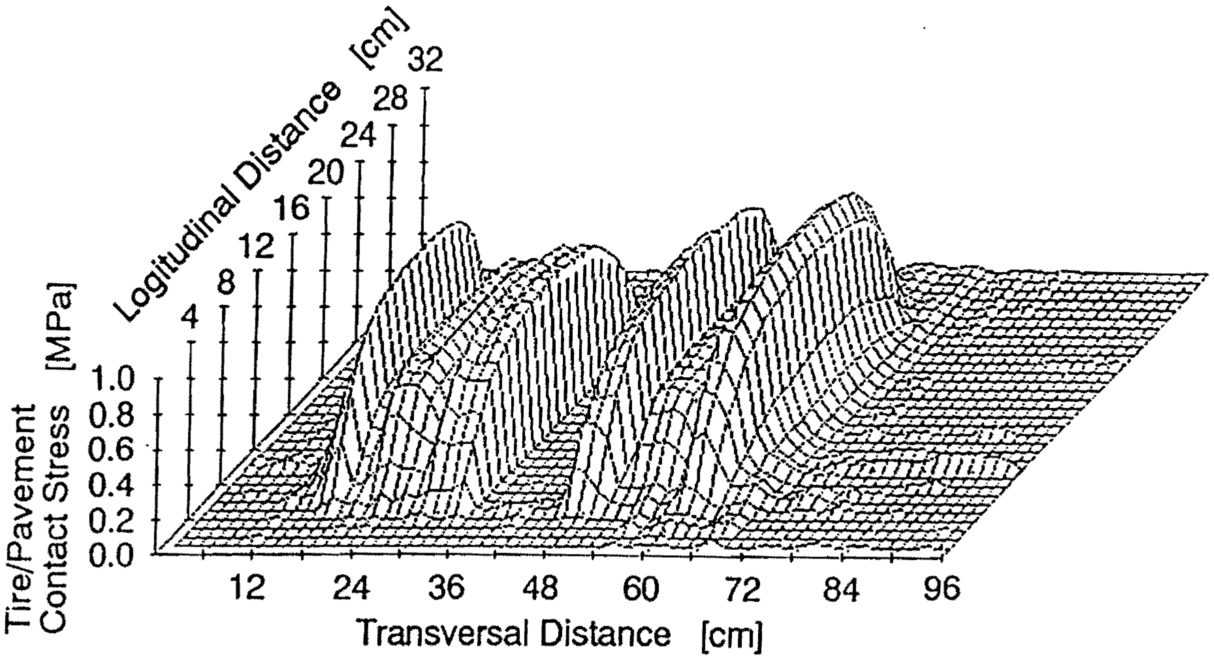

Figure 19. An example of tire/pavement contact signal curves [4]. (1 MPA = 145 psi).

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